# 3.2 Gbps, 3.3 V, Low Noise, Transimpedance Amplifier

# ADN2880

## FEATURES

**Bandwidth: 2.5 GHz**
**Optical sensitivity: −24.2 dBm[1]**
**Differential transimpedance: 4400 V/A**
**Power dissipation: 70 mW**
**Differential output swing: 260 mV p-p**
**Input overload current: 4.3 mA p-p**
**On-chip RSSI function**
**Low frequency cutoff: 20 kHz**
**On-chip PD filter: $R_F$ = 200 Ω, $C_F$ = 20 pF**
**Die size: 0.7 mm × 1.2 mm**

## APPLICATIONS

**3.2 Gbps or below optical receivers**
**SONET/GbE/FC optical receivers**
**SFF-8472-compliant receivers**
**PIN/APD-TIA receive optical subassemblies (ROSA)**

## GENERAL DESCRIPTION

The ADN2880 is a 3.3 V, high gain SiGe transimpedance amplifier (TIA). The TIA converts the small signal current of a photo detector into differential voltage output. The ADN2880 features a 315 nA typical input-referred noise, enabling an optical sensitivity of −24.2 dBm (0.85 A/W PIN). With a bandwidth of 2.5 GHz, the ADN2880 allows a data rate operation up to 3.2 Gbps. Typical power dissipation is approximately 70 mW.

To facilitate the assembly in small form factor packages, such as TO-46 headers, the ADN2880 provides an on-chip RC filter (200 Ω, 20 pF) and features a 20 kHz low frequency cutoff without using an external capacitor. An on-chip RSSI circuit, which generates a voltage proportional to the average photodiode current, is also available for power monitoring and assembly alignment.

The ADN2880 is available in die form. With a chip area of 1.2 mm × 0.7 mm, the TIA layout is specifically optimized for TO-Can-based packages.

[1] Based on 1550 nm PIN, responsivity = 0.85 A/W, ER = 9 dB, BER < $10^{-10}$.

## FUNCTIONAL BLOCK DIAGRAM

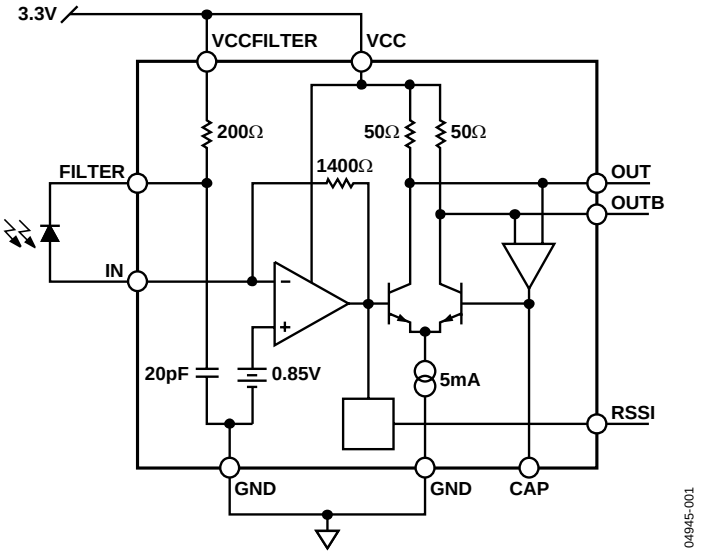


*Figure 1.*

**Rev. 0**
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## REVISION HISTORY

**7/05—Revision 0: Initial Version**

# ELECTRICAL SPECIFICATIONS

Minimum/maximum VCC = 3.3 V ± 0.3 V, $T_{AMBIENT}$ = −40°C to +95°C; typical VCC = 3.3 V, $T_{AMBIENT}$ = 25°C, unless otherwise noted.

**Table 1.**

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| DYNAMIC PERFORMANCE | | | | | |
| Bandwidth (BW)[1] | −3 dB | 1.9 | 2.5 | | GHz |
| Total Input Referred RMS Noise ($I_{RMS}$) | $C_D$ = 0.8 pF, dc to 2.1 GHz | | 315 | 485 | nA |
| Total Input Referred RMS Noise ($I_{RMS}$) | $C_D$ = 0.6 pF, dc to 2.1 GHz | | 300 | | nA |
| Small Signal Transimpedance ($Z_T$)[1] | 100 MHz, differential | 2700 | 4400 | 6200 | V/A |
| | 100 MHz, single-ended | 1350 | 2200 | 3100 | V/A |
| Low Frequency Cutoff | CAP = open, $I_{IN}$ = 20 µA | | 20 | | kHz |
| | CAP = 1 nF, $I_{IN}$ = 20 µA | | 1.0 | | kHz |
| Output Return Loss | DC to 3.5 GHz, differential | | −26 | −20 | dB |
| Input Overload Current | ER = 10 dB, at 95°C[1] | 2.1[1] | 4.3 | | mA p-p |
| Maximum Differential Output Swing | $I_{IN, P-P}$ = 2.0 mA | 170 | 260 | 375 | mV p-p |
| Output Data Transition Time | $I_{IN, P-P}$ = 1.0 mA; 20% to 80% rise/fall time | | 60 | | ps |
| PSRR | $I_{IN}$ = 0 mA, <10 MHz | | 39 | | dB |
| Group Delay Variation | 1.0 GHz to 3.0 GHz | | 50 | | ps |
| Transimpedance Ripple | 50 MHz to 1.0 GHz, single-ended | | 0.93 | | dB |
| Deterministic Jitter | 10 µA < $I_{IN, P-P}$ ≤ 100 µA, K28.5 @ 3.2 Gbps | | 16 | | ps p-p |
| | 100 µA < $I_{IN, P-P}$ ≤ 2.0 mA, K28.5 @ 3.2 Gbps | | 25 | | ps p-p |
| | 10 µA < $I_{IN, P-P}$ ≤ 2.0 mA, PRBS $2^{31}$ − 1 at OC48 (FEC) | | 38 | | ps p-p |
| Linear Output Range | Differential, <1 dB compression | | 210 | | mV p-p |
| Linear Input Current Range | Single-ended, <1 dB compression | | 53 | | µA p-p |
| DC PERFORMANCE | | | | | |
| Power Dissipation | $I_{IN, AVE}$ = 0 mA | | 70 | 110 | mW |
| Input Voltage | Compliance voltage | | 0.85 | | V |
| Output Common-Mode Voltage | DC (50 Ω) terminated to VCC | | VCC − 0.12 | | V |
| Output Impedance | Single-ended | | 50 | | Ω |
| PD FILTER Resistance | $R_F$ | | 200 | | Ω |
| PD FILTER Capacitance | $C_F$ | | 20 | | pF |
| RSSI Gain | $I_{IN, AVE}$ = 5 µA to 1 mA | | 0.85 | | V/mA |
| RSSI Offset | $I_{IN, AVE}$ = 10 µA | | 8.0 | | mV |
| RSSI Accuracy | 5 µA < $I_{IN, P-P}$ ≤ 20 µA | | ±7 | | % |
| | 20 µA < $I_{IN, P-P}$ ≤ 1 mA | | ±3 | | % |

[1] An equivalent $I_{IN, P-P}$ = 13 µA current signal is applied to the TIA input. No input capacitor is applied.

# ABSOLUTE MAXIMUM RATINGS

**Table 2.**

| Parameter | Rating |
|---|---|
| Supply Voltage (VCC to GND) | 5 V |
| Maximum Voltage to All Input and Output Signal Pins | VCC + 0.4 V |
| Minimum Voltage to All Input and Output Signal Pins | GND – 0.4 V |
| Maximum Input Current | 10 mA |
| Storage Temperature Range | –65°C to +125°C |
| Operating Ambient Temperature Range | –40°C to +95°C |
| Maximum Junction Temperature | 125°C |
| Die Attach Temperature (<30 sec) | 410°C |

Stresses above those listed under Absolute Maximum Rating may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

# PAD LAYOUT AND FUNCTION DESCRIPTIONS

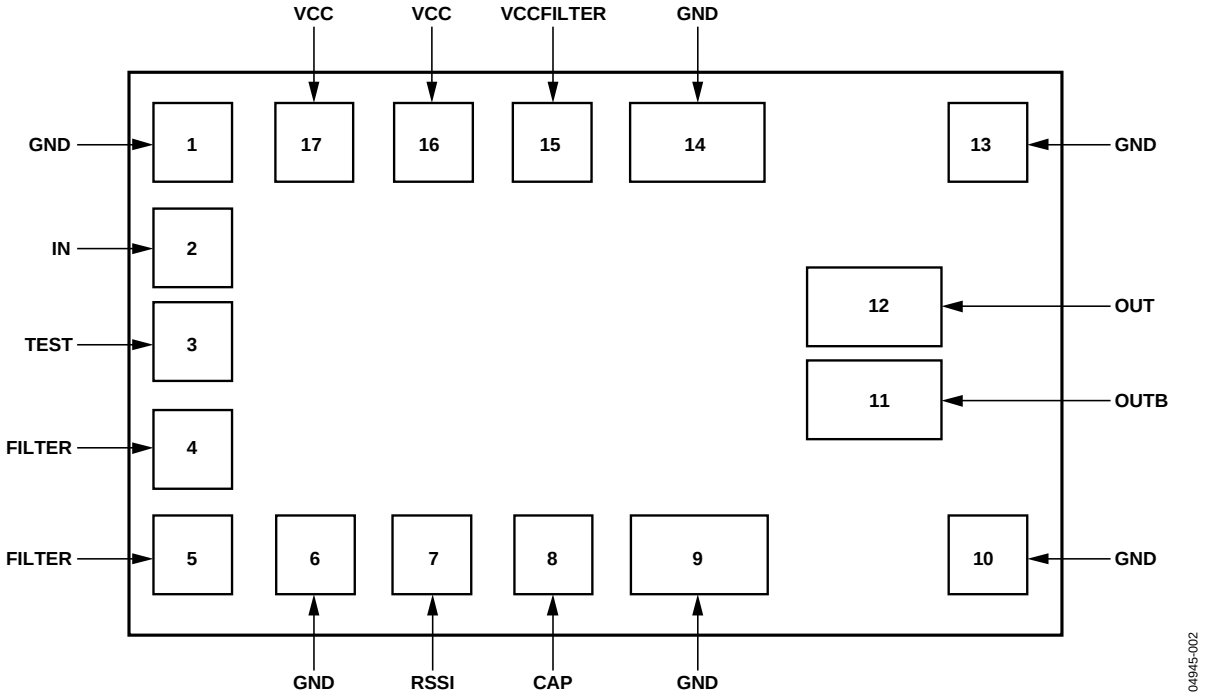


*Figure 2. Pad Layout*

**Table 3. Pad Function Descriptions**

| Pad No. | Mnemonic | Pin Type[1] | Description |
|---|---|---|---|
| 1 | GND | P | Ground. (Input return.) |
| 2 | IN | AI | Current Input. Bond directly to a photodiode (PD) anode. |
| 3 | TEST | AI | Test Probe Pad. Do not connect. |
| 4, 5 | FILTER | AO | Filter Output. Pad 4 and Pad 5 are metal connected. Optional bond to a PD cathode. |
| 6 | GND | P | Ground. |
| 7 | RSSI | AO | Voltage Output. Provides average input current monitoring. If not used, connect to ground. |
| 8 | CAP | AI | Low Frequency Cutoff (LFC) Setpoint. For SONET applications, see Figure 10 and contact sales for assembly details. |
| 9, 10, 13, 14 | GND | P | Ground. (Output return.) |
| 11 | OUTB | AO | Negative Output, CML, On-Chip 50 Ω Termination (AC or DC Termination). |
| 12 | OUT | AO | Positive Output, CML, On-Chip 50 Ω Termination (AC or DC Termination). |
| 15 | VCCFILTER | P | On-Chip Filter Supply. Connect to VCC to Enable On-Chip RC Filter (200 Ω, 20 pF). Leave unconnected if not used. |
| 16, 17 | VCC | P | 3.3 V Supply. Place a 200 pF, RF decoupling capacitor close to the power pad to reduce the power noise. |

[1] P = power; AI = analog input; and AO = analog output.

# TYPICAL PERFORMANCE CHARACTERISTICS

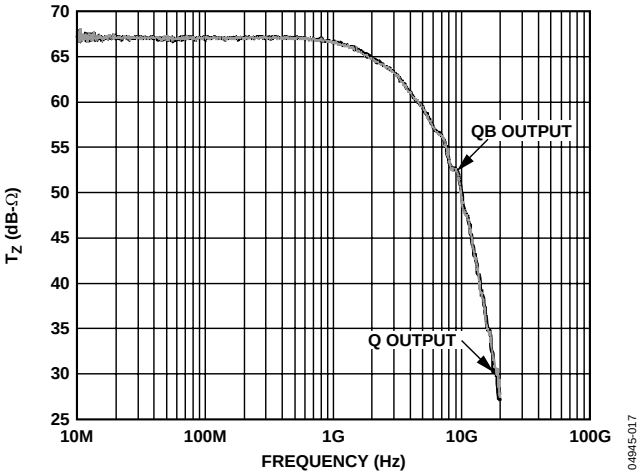


*Figure 3. Single-Ended Transimpedance vs. Frequency*

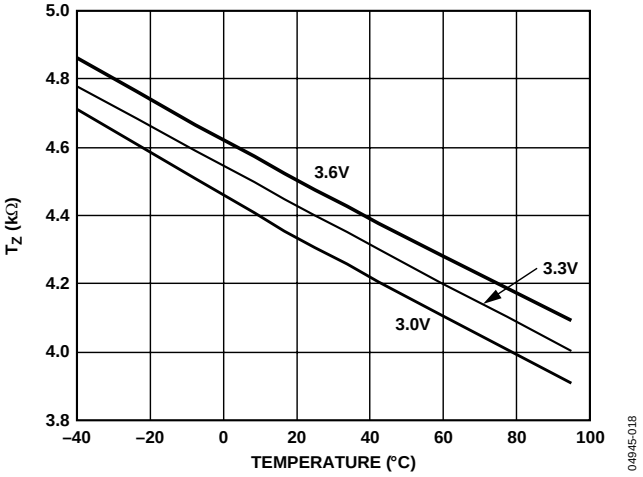


*Figure 4. Differential Transimpedance vs. VCC and Temperature*

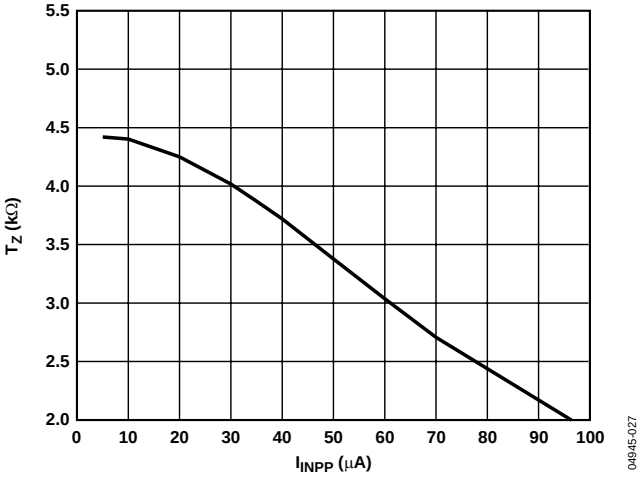


*Figure 5. Differential Transimpedance vs. Input Current*

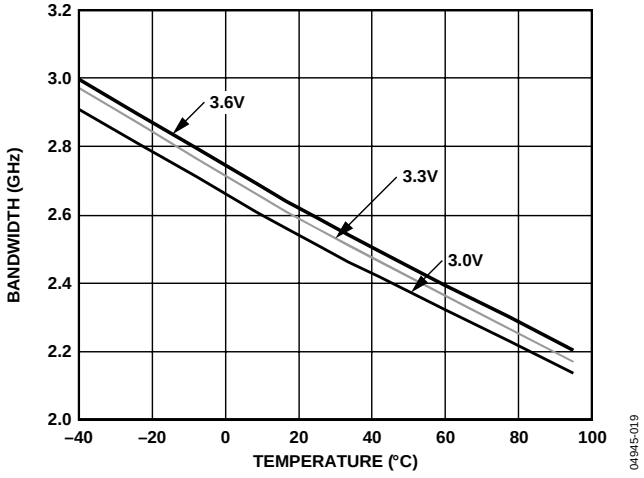


*Figure 6. Bandwidth vs. VCC and Temperature*

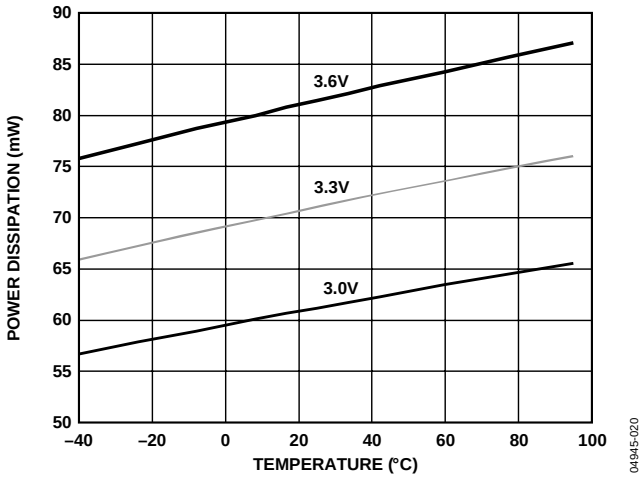


*Figure 7. Power Dissipation vs. VCC and Temperature*

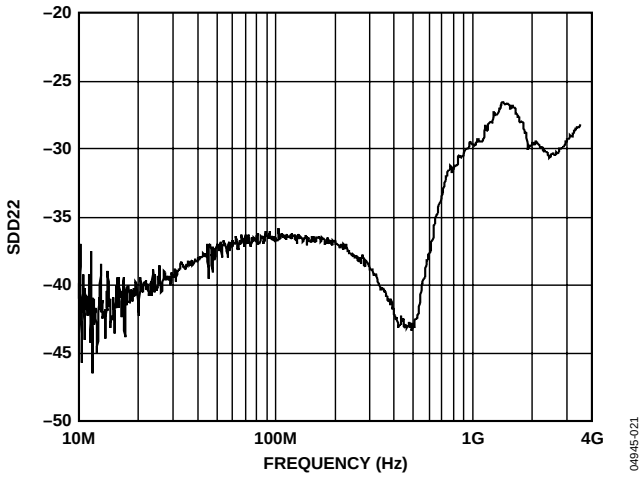


*Figure 8. SDD22 vs. Frequency up to 3.5 GHz, CAP = Open*

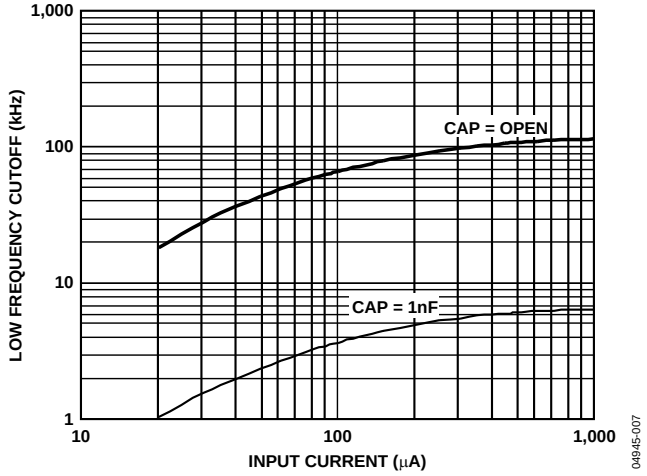


Figure 9. Low Frequency Cutoff vs. Input Current

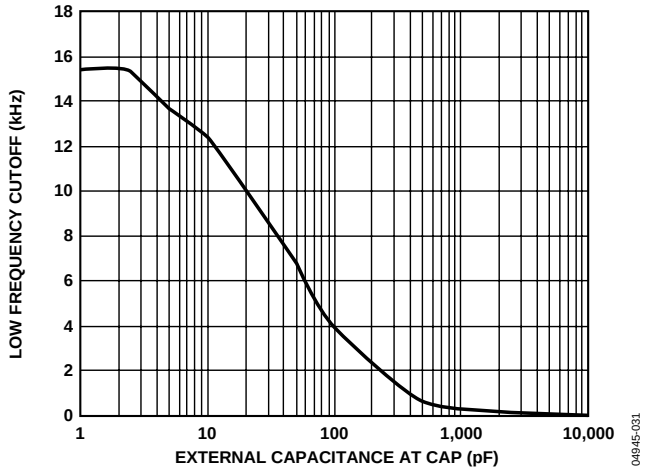


Figure 10. Low Frequency Cutoff vs. Capacitance at CAP

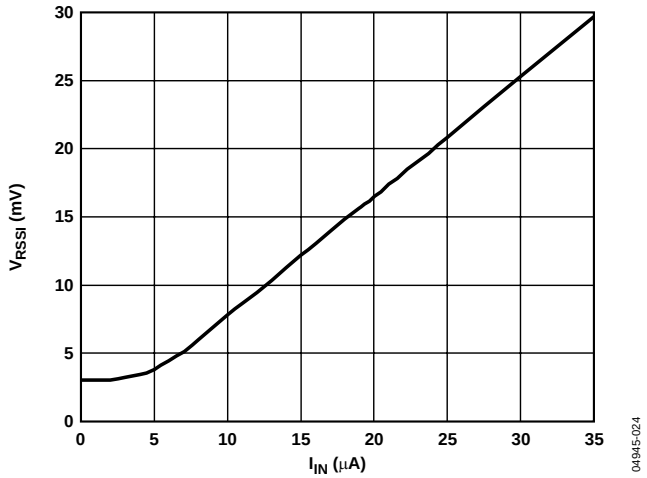


Figure 11. RSSI Voltage Output vs. Input Current (0 µA to 35 µA)

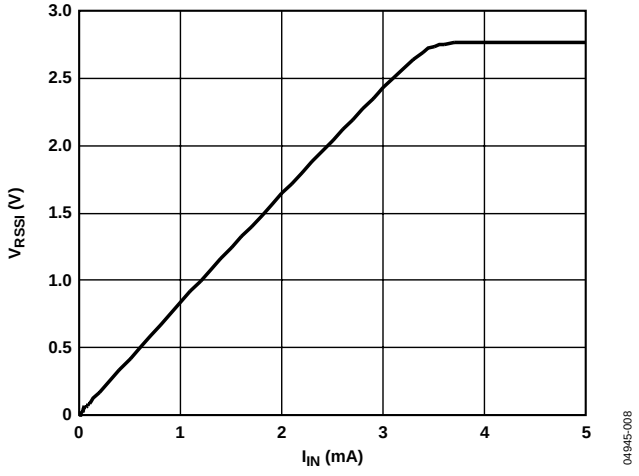


Figure 12. Full-Scale of RSSI Voltage Output vs. Input Current

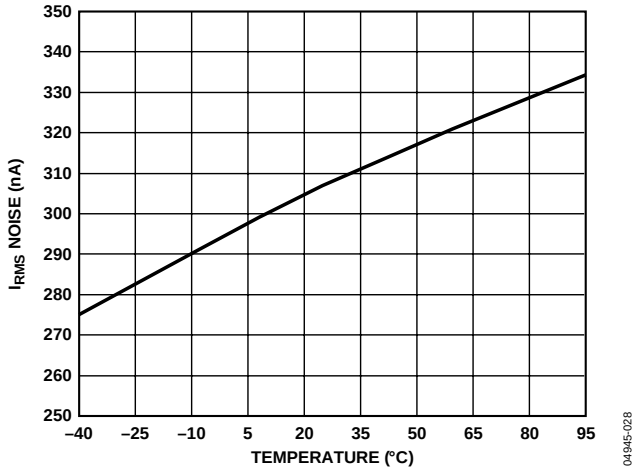


Figure 13. Input Noise vs. Temperature with 2 GHz Low-Pass Filter

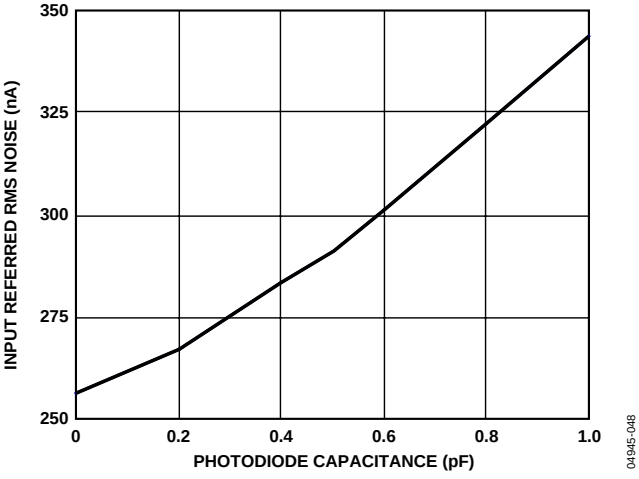


Figure 14. Input Referred Noise (DC to 2.0 GHz) vs. Photodiode Capacitance $C_D$ (pF)

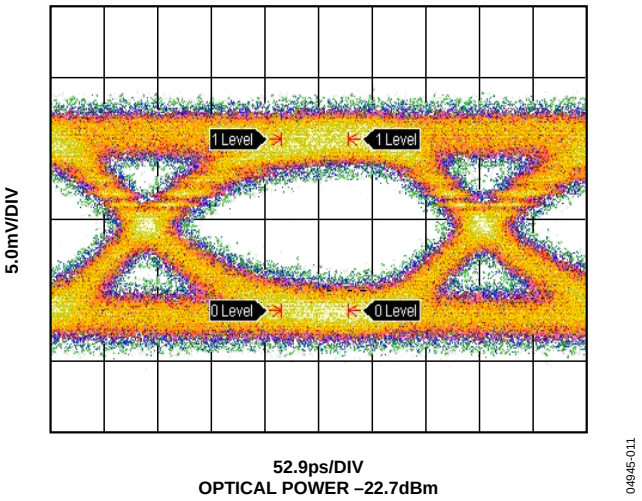


*Figure 15. Output Eye at 3.2 Gbps with BER <$10^{-10}$ (Based on a 1550 nm PIN, Responsivity = 0.91 A/W, ER = 9 dB, PRBS $2^{31}$)*

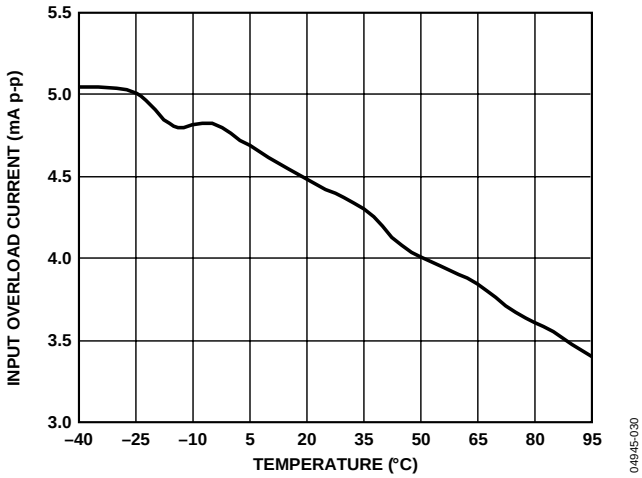


*Figure 17. Input Overload Current vs. Temperature*

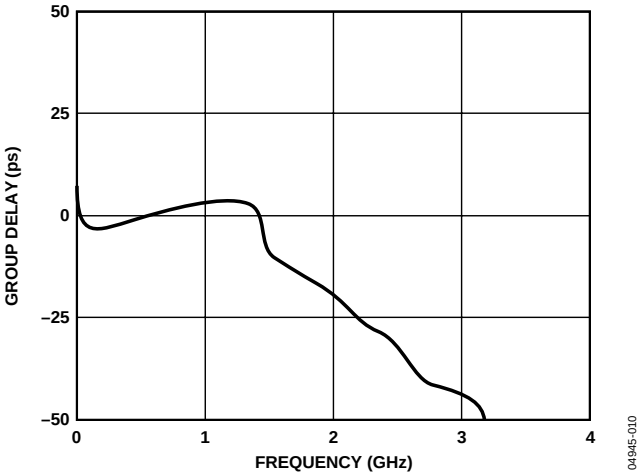


*Figure 16. Group Delay vs. Frequency*

# ASSEMBLY RECOMMENDATIONS

**Coplanar PIN Photodiode for SDH/SONET**

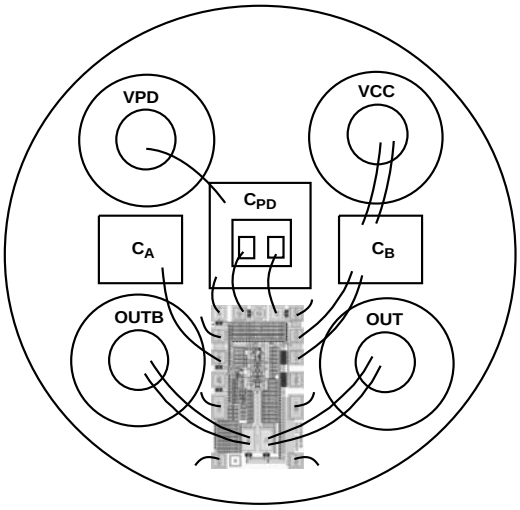


*Figure 18. 5-Pin TO-46 with External Photodiode Supply $V_{PD}$ Connected Through the FILTER Pin*

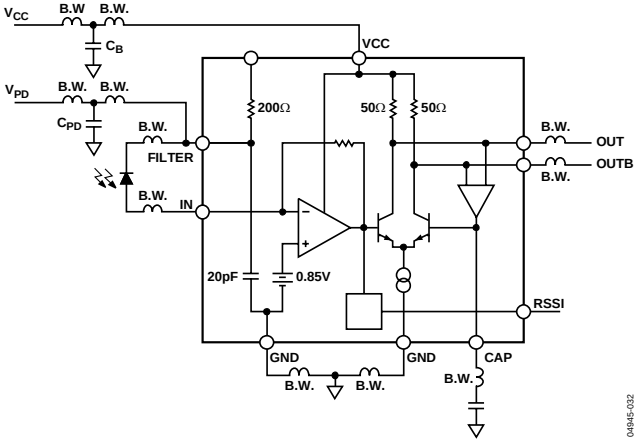


*Figure 19. Equivalent Circuit of the Assembly Including Bond Wires*

**Dual Planar PIN/APD Photodiode for SDH/SONET**

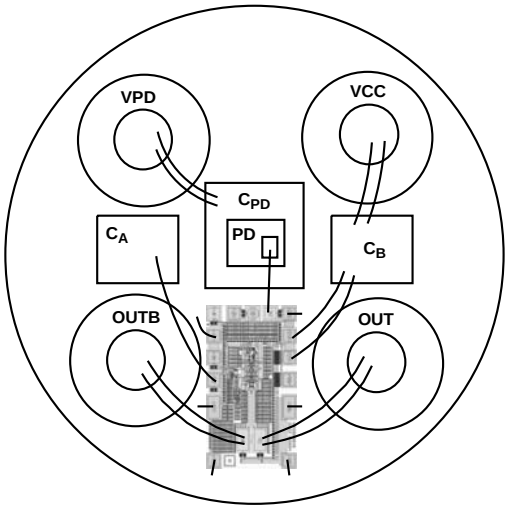


*Figure 20. 5-Pin TO-46 with External Photodiode Supply $V_{PD}$ to a Dual Planar PIN or APD*

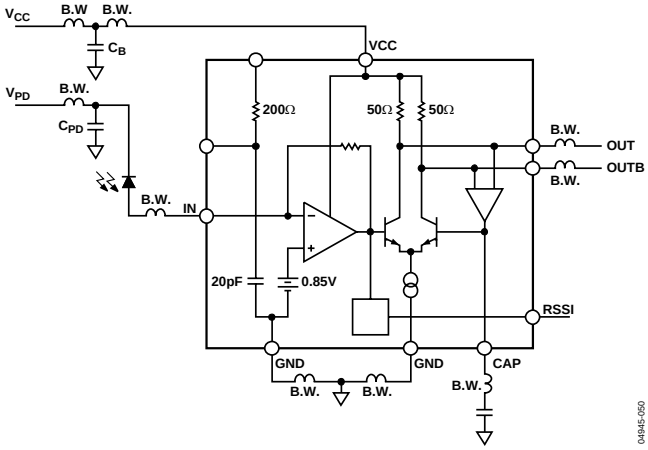


*Figure 21. For Dual Planar PDs, No Connection to FILTER Pin*

**Table 4. Bill of Materials (BOM)**

| Component | Description |
|---|---|
| PD | 1× vendor specific, 2.5 Gbps, photodiode |
| TIA | 1× ADN2880 (0.7 mm × 1.2 mm), 3.2 Gbps, transimpedance amplifier |
| $C_B$ | 1× 200 pF, RF single-layer capacitor |
| $C_{PD}$ | 1× 560 pF, RF single-layer capacitor |
| $C_A$ | 1× 1000 pF, ceramic capacitor (optional for SDH) |

**Notes**

One mil thickness, gold wire, ball bond recommended.

Minimize all GND bond-wire lengths.

Minimize IN, FILTER, OUT, and OUTB bond-wire lengths.

Maintain symmetry in length and orientation between OUT and OUTB bond wires.

Maintain symmetry in length and orientation between IN and FILTER bond wires.

Maintain symmetry between IN/FILTER and OUT/OUTB bond wires.

**PIN Photodiode for a Non-SDH/SONET Application**

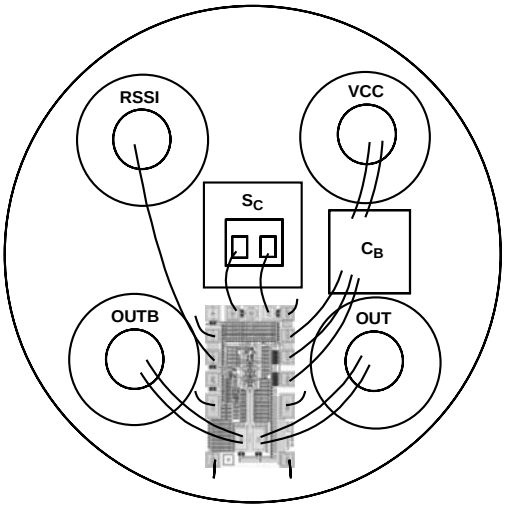


*Figure 22. Coplanar PIN and RSSI Layout for a 5-Pin TO-46*

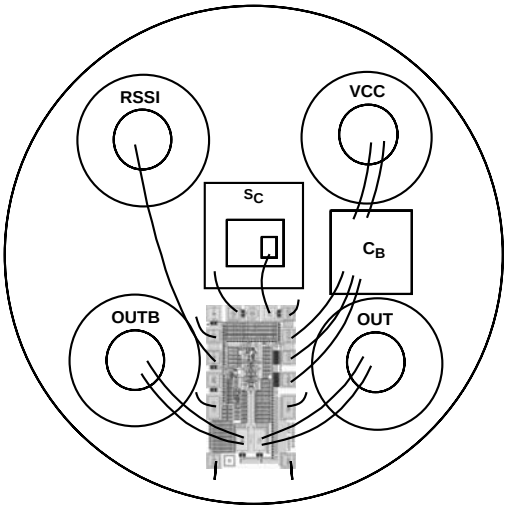


*Figure 24. Dual Planar PIN and RSSI Layout for a 5-Pin TO-46*

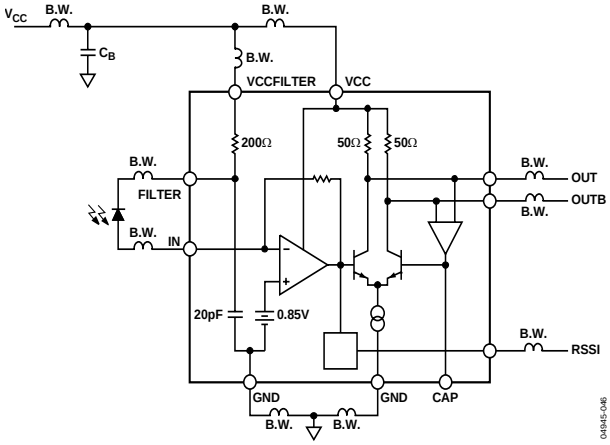


*Figure 23. Equivalent Circuit with Bond Wires, as Shown in Figure 22*

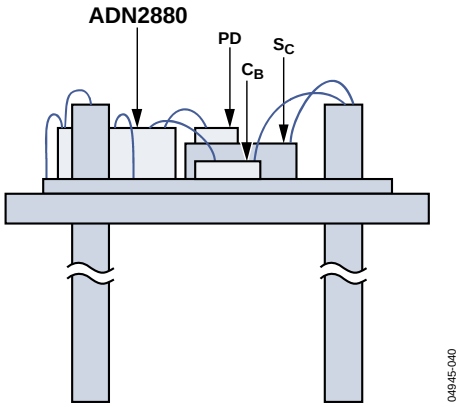


*Figure 25. Side View of the Assembly, as Shown in Figure 22*

**Table 5. Bill of Materials (BOM)**

| Component | Description |
|---|---|
| PD | 1× vendor specific, 2.5 Gbps, photodiode |
| TIA | 1× ADN2880 (0.7 mm × 1.2 mm), 3.2 Gbps, transimpedance amplifier |
| $C_B$ | 1× 200 pF, RF single-layer capacitor |
| Sc | 1× ceramic standoff or 1× optional capacitor |

**Notes**

One mil thickness, gold wire, ball bond recommended.

Minimize all GND bond-wire lengths.

Minimize IN, FILTER, OUT, and OUTB bond-wire lengths.

Maintain symmetry in length and orientation between OUT and OUTB bond wires.

Maintain symmetry in length and orientation between IN and FILTER bond wires.

Maintain symmetry between IN/FILTER and OUT/OUTB bond wires.

**PIN Photodiode for Non-SDH/SONET Applications**

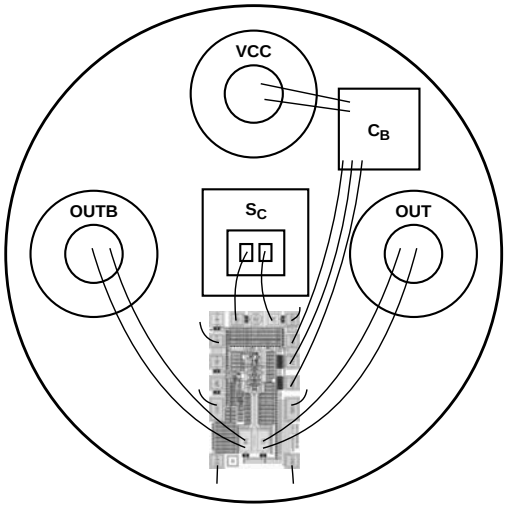


*Figure 26. Coplanar PIN for a 4-Pin TO-46*

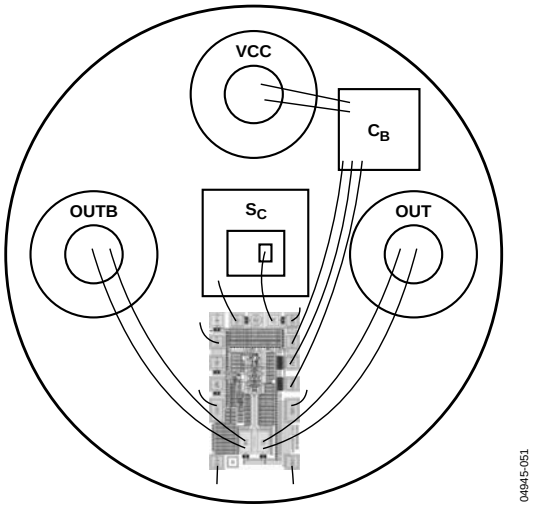


*Figure 28. Dual Planar PIN for a 4-Pin TO-46*

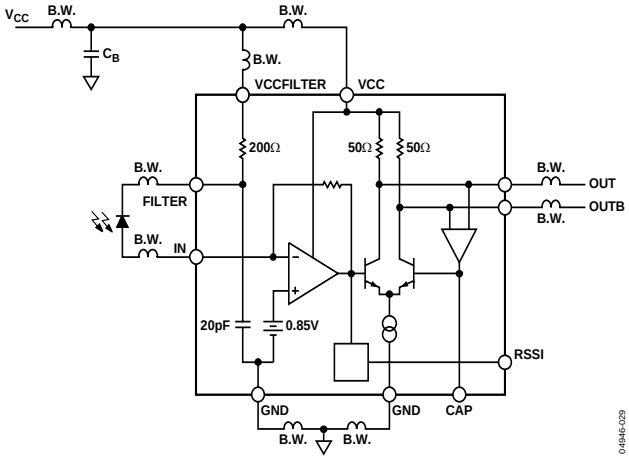


*Figure 27. Equivalent Circuit with Bond Wires, as Shown in Figure 26*

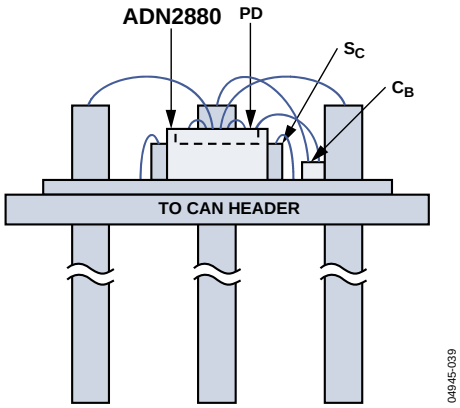


*Figure 29. Side View of the Assembly, as Shown in Figure 26*

**Table 6. Bill of Materials (BOM)**

| Component | Description |
|---|---|
| PD | 1× vendor specific, 2.5 Gbps, photodiode |
| TIA | 1× ADN2880 (0.7 mm × 1.2 mm), 3.2 Gbps, transimpedance amplifier |
| $C_B$ | 1× 200 pF, RF single-layer capacitor |
| Sc | 1× ceramic standoff or 1× optional 1000 pF capacitor |

**Notes**

One mil thickness, gold wire, ball bond recommended.

Minimize all GND bond-wire lengths.

Minimize IN, FILTER, OUT, and OUTB bond-wire lengths.

Maintain symmetry in length and orientation between OUT and OUTB bond wires.

Maintain symmetry in length and orientation between IN and FILTER bond wires.

Maintain symmetry between IN/FILTER and OUT/OUTB bond wires.

# OUTLINE DIMENSIONS

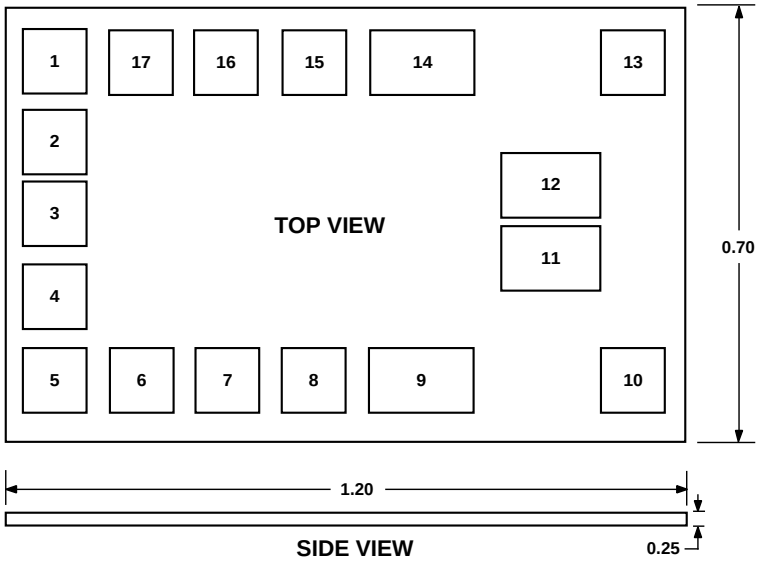


*Figure 30. 17-Pad Bare Die Sales [CHIP]*
*Dimensions shown in millimeters*

**Table 7. Pad Coordinates**

| Pad No. | Mnemonic | X (µm) | Y (µm) |
|---|---|---|---|
| 1 | GND | −500 | +260 |
| 2 | IN | −500 | +130 |
| 3 | TEST | −500 | +10 |
| 4 | FILTER | −500 | −120 |
| 5 | FILTER | −500 | −260 |
| 6 | GND | −350 | −260 |
| 7 | RSSI | −200 | −260 |
| 8 | CAP | −50 | −260 |
| 9 | GND | +130 | −260 |
| 10 | GND | +500 | −260 |
| 11 | OUTB | +350 | −60 |
| 12 | OUT | +350 | +60 |
| 13 | GND | +500 | +260 |
| 14 | GND | +130 | +260 |
| 15 | VCCFILTER | −50 | +260 |
| 16 | VCC | −200 | +260 |
| 17 | VCC | −350 | +260 |

## DIE INFORMATION

### *Die Size*

0.7 mm × 1.2 mm (edge-to-edge, including 1 mil scribe)

### *Die Thickness*

10 mils = 0.25 mm

### *Passivation Openings*

0.075 mm × 0.075 mm (Pad 1 to Pad 8, Pad 10, Pad 13, Pad 15 to Pad 17)

0.144 mm × 0.075 mm (Pad 9, Pad 11, Pad 12, Pad 14)

### *Passivation Composition*

5000 Å $Si_3N_4$ (top)

5000 Å $SiO_2$ (bottom)

### *Pad Composition*

Al/1%Cu

### *Substrate Contact*

To ground

## ORDERING GUIDE

| Model | Temperature | Package Description |
|---|---|---|
| ADN2880ACHIPS | −40°C to +95°C | 17-Pad Die Sales |

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